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Substitution of Hazardous substances in Process industry using results of Life Cycle Assessment (LCA)

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- **Substitution of target substances**
- **Good Practice Comparative LCA of Water-based and Solvent-based Primer Paints for Steel Plate Priming**
- **Benefits from LCA**

Use of hazardous substances in industrial companies in EU

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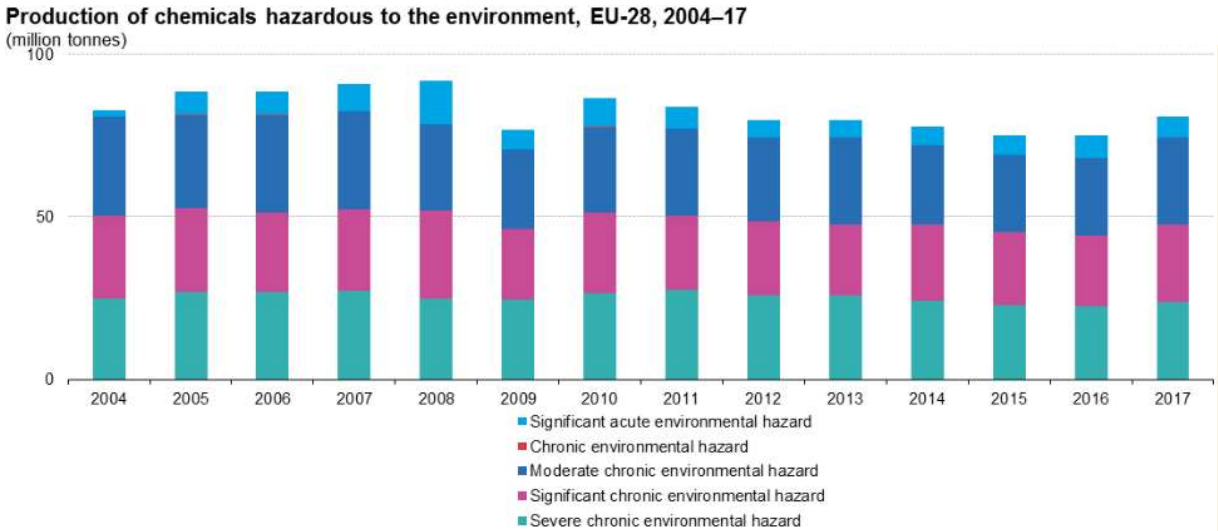

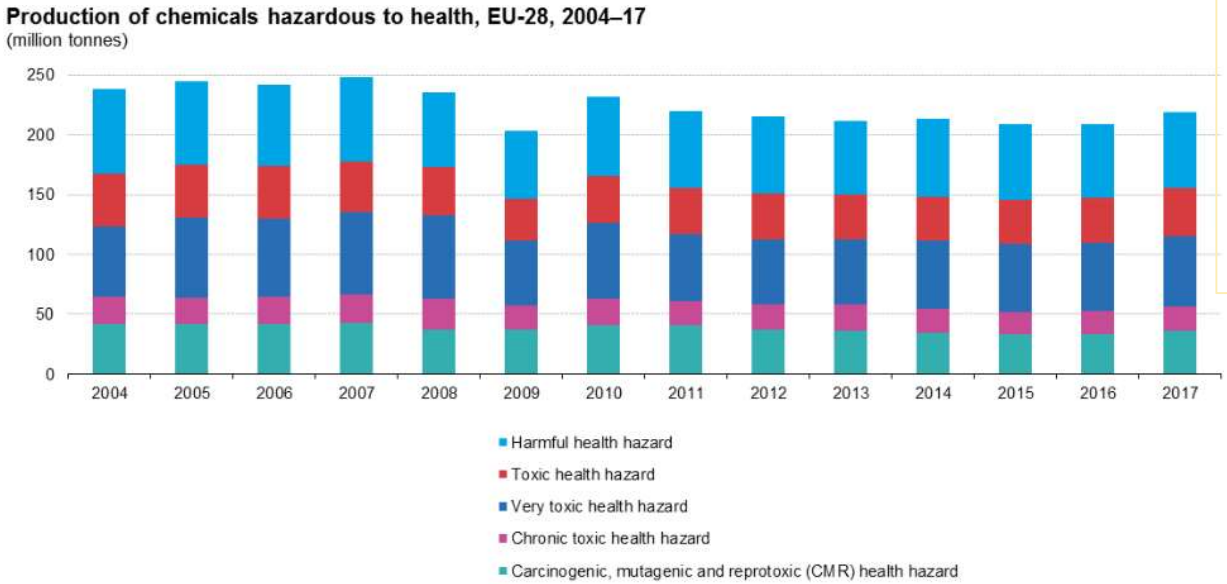

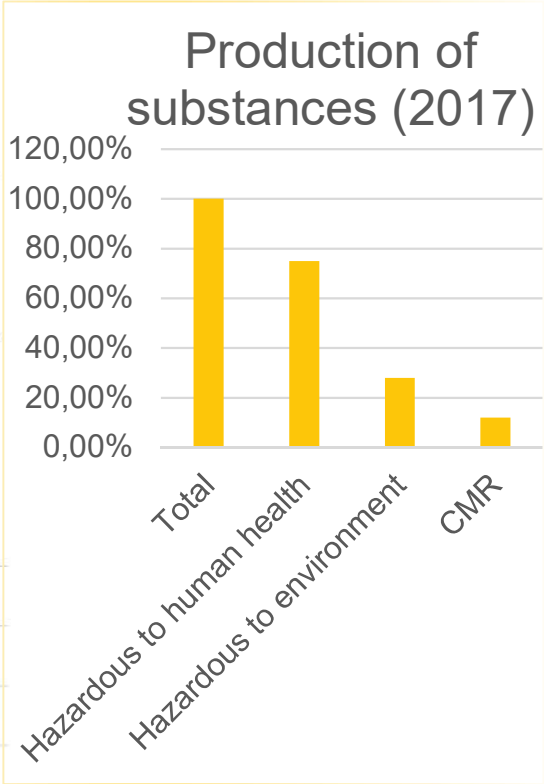

Source: Eurostat

Substitution of hazardous substances

- **Substitution** means the **replacement or reduction of hazardous substances in products and processes** by less hazardous or non-hazardous substances, or by achieving an equivalent functionality via technological or organisational measures
- Substitution may be **voluntary**, though not a common practice. Usually it happens when a company wants to get **eco-label** or implement the **EMS** ISO14001
- Sometimes **substitution is demanded by customers** with more stringent requirements in the field for hazardous substances
- Substitution can also be **mandatory**, as required by **EU legislation on chemicals** (*such as REACH with restrictions on certain uses or a complete ban on a number of substances*)
- It is required when the **manufacture, use or disposal poses** an **unacceptable risk to Human health and Environment**

Case study – Metalworking company

Cleaning, priming and cutting of metal sheets and profiles, intended mostly for ship building and repair

- Nowadays, hazardous substances such as volatile organic compounds (VOCs) are still being used as solvents and released in many technological processes of different industries, as for example metal priming processes
- In the company where case study was applied, the problematic substances are different VOCs, which are emitted in amounts nearly 46 thousand t per year, what is over the permitted emission limit values
- The analysed company were exceeding the VOC emission limits and were using hazardous substances listed in Industrial Emissions Directive (IED) (2010/75/EU) (EU 2010) and Paints Directive 2004/42/EC (EU 2004)
- **Company case: metal sheet priming**

Substance	EC no	Candidate list SVHC *(because of...)*	CMR	Env. hazards	Other health hazards
Xylene	215-535-7	–	–	–	H312, H315, H332
2-methoxy-propanol	216-455-5	–	Repr. 1B H360D	–	H315, H318, H335
1-methoxy-2-propanol	203-539-1	–	–	–	H 336
Ethylbenzene	202-849-4	–	–	–	H332, **H373**, H304

➢ **LIFE+ "FIT for REACH", 2016-2020 , The project "Baltic pilot cases on reduction of emissions by substitution of hazardous chemicals and resource efficiency"**

Identification of hazardous substances

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- **Company case: metal sheet priming**

Metal processing (metal sheet priming): VOCs + Xylene (organ toxicity)+2-methoxypropanol (reprotoxic 1B)

- **Identification alternative**

Substance	EC no	Candidate list SVHC *(because of...)*	CMR	Env. hazards	Other health hazards
Propan-2-ol	200-661-7	–	–	–	H319, H336
Toluene	203-625-9	–	Repr. 2 H361d	–	H315, H336, **H373**, H304
Xylene	215-535-7	–	–	–	H312, H315, H332
Ethylbenzene	202-849-4				H332, **H373**, H304
Solvent naphtha (petroleum) light aromatic	265-199-0	–	–	**411**	H332, H315, H319, H335, H304

Note: orange colour outlines the target substances.

The frame of the Life cycle assessment:

Public authorities have been negotiating with the company to achieve conformity with EU requirements

Goal:

- **to assess the difference in Life cycle environmental impacts by comparing two thinners that are used in a two-component shop primer as part of a coating system intended for priming of metal sheets**

Functional unit:

- **coverage of 1 m2 of metal sheets with a single layer of interoperational primer**

LCA system boundaries for VOC substitution:

- **raw materials, transportation and production**

The service life of the metal sheets and their disposal stages were not covered because they were not relevant (VOCs evaporate already during the production stage)

Case study methodology

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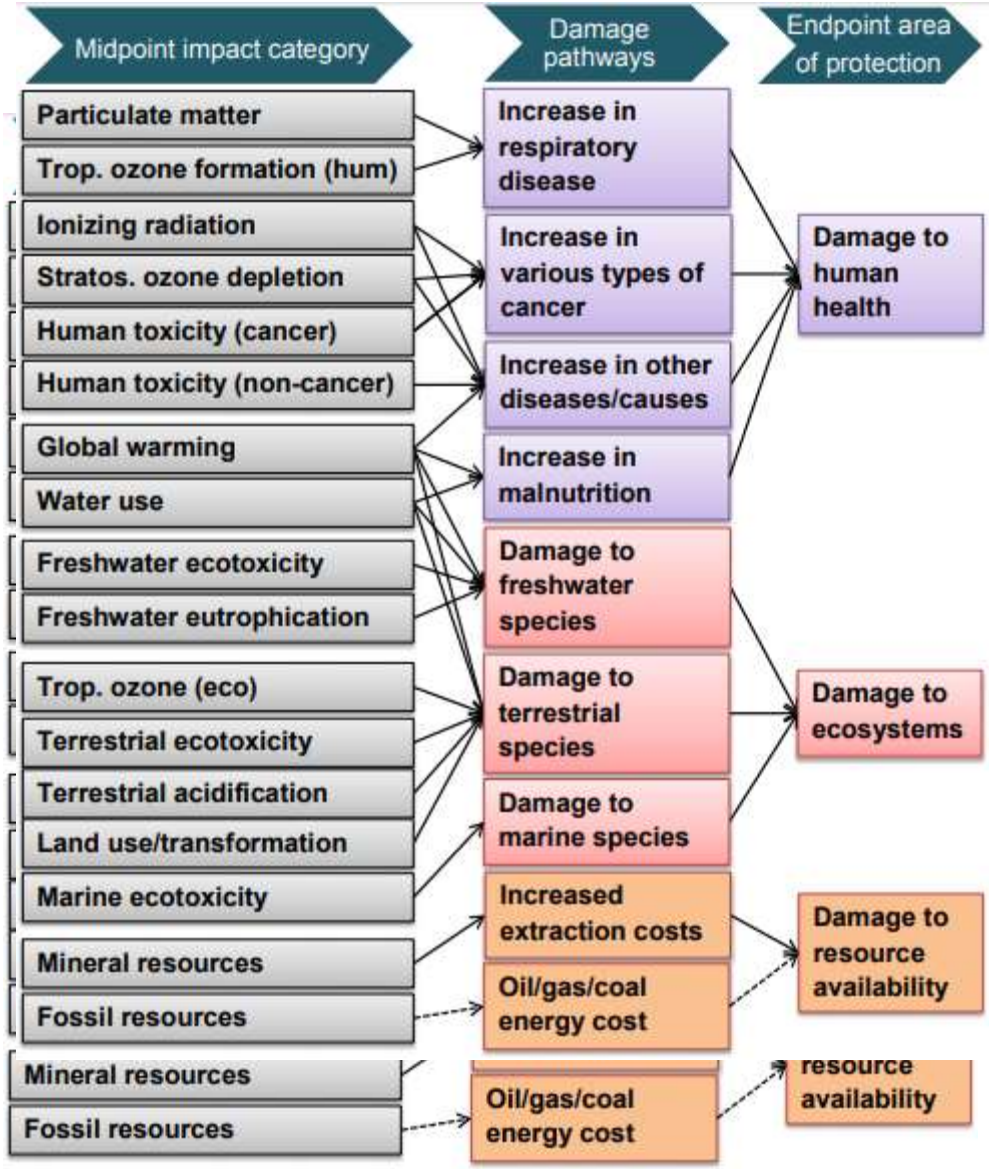
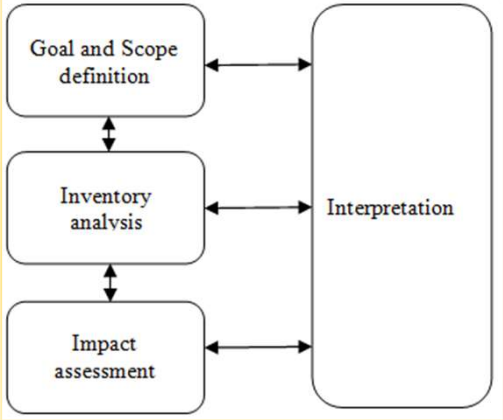


Source: Huijbregts et al., 2016

Simplified LCA uses:

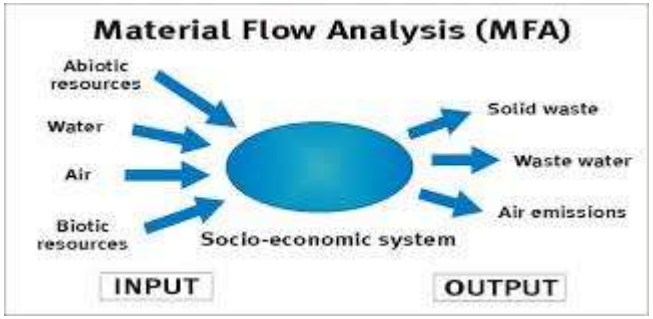
- **Target process MFA**
- **ReCiPe 2016 endpoint method**
- **Ecoinvent LCI database**
- **Intended emissions**
- **Global/regional impact scope**



Source: ISO 14044

Identification of Hazardous substances

- **Company level Materials Flow Analysis (MFA)**



- **Compare MFA results to existing SVHC lists to identify any SVHC**
- **Existing SVHC lists:**

  - Authorisation list, candidate list and restriction lists by ECHA
  - Sin list by ChemSec

Identification of the alternatives

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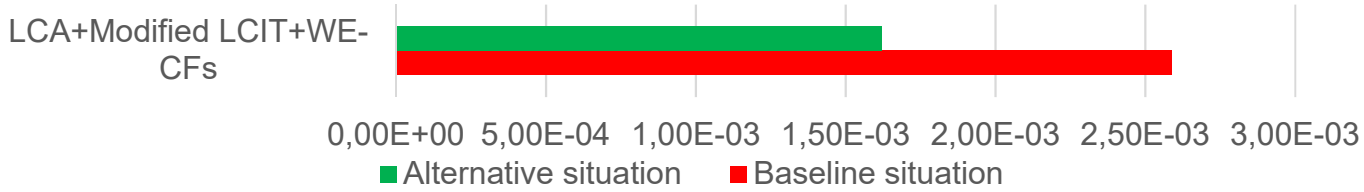
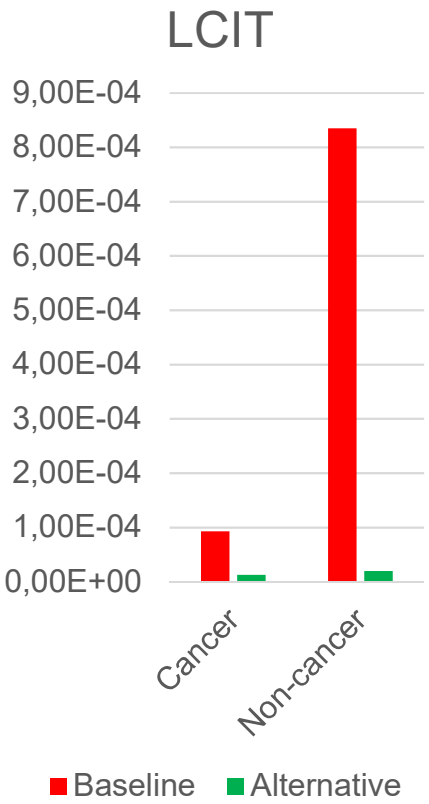
Alternatives can be identified in many ways:

- **Subsport database**
- **ECHA substitution cases**
- **Company contacts**
- **Various seminars held for dissemination of substitution practices in companies**

Metal sheet priming case





Baseline	Hazard type	Suspected (kg)	Animal studies (kg)	Known (kg)
Total usage along life cycle (worker impacts)	Reprotoxicity	0	7.16E-6	0
	Endocrine disruption	0	0	0
	Highly flammable/explosive/reactive	N/A	N/A	8.76E-3
	Carcinogenic/mutagenic	4.80E-4	N/A	N/A
Total emission from company (human health and environmental impacts)	Reprotoxicity	0	0	0
	Endocrine disruption	0	0	0
	PBT and vPvB	N/A	N/A	0
	Carcinogenic/mutagenic	0	N/A	N/A
Alternative	**Hazard type**	**Suspected (kg)**	**Animal studies (kg)**	**Known (kg)**
Total usage along life cycle (worker impacts)	Reprotoxicity	2.11E-3	0	0
	Endocrine disruption	0	0	0
	Highly flammable/explosive/reactive	N/A	N/A	7.01E-3
	Carcinogenic/mutagenic	0	N/A	N/A
Total emission from company (human health and environmental impacts)	Reprotoxicity	2.11E-3	0	0
	Endocrine disruption	0	0	0
	PBT and vPvB	N/A	N/A	0
	Carcinogenic/mutagenic	0	N/A	N/A

Results

- The study results showed the importance of conducting a formal LCA study, and the shortcomings of local informal non-standardised assessments
- The LCA of 2 shop primer products showed, in this specific case, that the water-based shop primer was **environmentally preferable** for almost all the environmental impact categories. All the impact categories showed more than **34% decrease in environmental impact**, which is a very good justification for the substitution from an environmental perspective
- The biggest decrease, more than **50%**, was observed in ozone depletion, freshwater eutrophication, human toxicity, particulate matter formation, ionising radiation, and metal depletion
- Overall, the results indicated the importance of conducting Life cycle assessment for **decision-making** as many impacts are not intuitively obvious

Conclusions

In this study:

- Life cycle assessment (LCA) was used to justify product substitution in a company due to regulatory concerns
- Supportive communication from the Environmental Protection Agency was the background for the LCA project initiation
- The results indicated that the substitution to the less hazardous substances was beneficial for the company not only from environmental point of view, but also from simplified work safety requirements, compliance with requirements of the law and resource efficiency
- The results indicated that the substitution to the water based primer paint was beneficial in all environmental impact categories

Life cycle assessment

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- **The main benefits and why the hazardous substances should be substituted:**
  - **smaller hazardous waste management costs;**
  - **simpler chemical inventory;**
  - **simplified work safety requirements;**
  - **on the market product can be positioned as consumer health and environmentally friendly;**
  - **compliance with requirements of the law, which are or will come into force in the near future;**
  - **substitution may enable new innovations and resource efficiency;**
  - **changes in product costs;**
  - **and etc.**
  - **LCA could be useful for any processing industry, where hazardous chemicals are used**

How should You start?

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If you have found out that you have substitution candidates (*substances as such or substances in mixtures and articles*), **prioritise which case(s) you would like to start with**

Criteria for prioritization could be:

- (Future) legal pressure (substance will be prohibited or restricted)
- Problems for workers protection (e.g. obvious from workplace risk assessment, worker feed-back etc.)
- High costs for environmental emission reduction, exceedance of environmental emission limit values
- Requests from your clients
- Company policy to phase out (certain) hazardous chemicals

- Ask the environmental specialists in your company and communicate with your suppliers of raw materials
- Think about the key properties or functions that you need
- Identify the scope and complexity of substitution

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Thank you!

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Questions welcome

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